

# Clay soil fulgurites in the Eastern Goldfields of Western Australia

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## Abstract

Discovery of two fresh lightning strikes in the Eastern Goldfields of Western Australia and observation of their features is considered to have confirmed that samples of highly vesicular glass regularly observed in this area of Western Australia are fulgurites. It is proposed to refer to them as "clay soil fulgurites" to distinguish them from the "sand fulgurites" which have been more readily identified and collected. One of the strikes was notable for the disturbance caused to the soil. Observations of this feature of the strike suggested that the moisture content of clay soils and subsoils plays an important role in determining the path taken by the electrical discharge and the production of fulgurites. This factor is considered to modify the primary features such as the intensity of a particular lightning discharge and the composition of the soil. The second strike resulted in a large vesicular glass fulgurite that is described here and has been presented to the Western Australian Museum.

## Introduction

Lumps of glassy vesicular material lying on the surface of the ground are commonly found by geologists during fieldwork in the southern parts of Western Australia. Many of these glassy fragments appear to have been lying exposed for some time and have an abraded appearance with surfaces covered in the red dust typical of the soils of the region. The size of these fragments varies; most are hand-sized but a few are somewhat larger. When visible the glass is usually a streaky grey to dull green to brown colour. These fragments are highly vesicular and light in weight. Trendall (1964) described a number of samples of similar glass in the collection of the Geological Survey of Western Australia and presented details of their microscopic structure and chemical composition. On the basis of a thorough review of the available data, Trendall (1964) concluded that they were probably formed by the fusion of soil by lightning, and suggested the name "fulgurite slag" for the material. I have noted these objects during work in central Africa and considered that were probably fulgurites, but had never observed them in a situation that provided any direct evidence of their origin.

This paper describes two specimens of glassy material, which apparently were discovered shortly after formation as indicated by observations of their occurrence. Their features are consistent with the fusion of clayey soil by lightning, and the name "clay soil fulgurite" is therefore suggested to distinguish them from other varieties such as the better-known "sand fulgurites" (e.g. Glover 1974).

## Observations

### First Discovery

In June 1984, the author was mapping on Avoca Downs Station, north of Randall on the Trans Australia

Railway Line. There had been thunderstorms in the area and what was interpreted to be a very recent lightning strike was recognised. The lightning had struck the ground on a low rise in a clearing amongst gum trees with only a very low and sparse vegetation covering the ground. The soil profile in the vicinity of the strike was complete with a surface crust of lichen and vegetation that has been destroyed on most pastoral areas. The point at which the deduced lightning discharge appeared to have entered the ground was marked by a small area less than 50 cm across where the ground surface had been greatly disturbed with small clods of soil having been thrown out onto the surrounding surface. On the patch of disturbed soil a fulgurite of partially fused material with a vesicular structure was lying. This was also judged to have been thrown into the air and to have dropped back onto the disturbed soil. The salient features of this strike are illustrated in Fig 1.

While there was some fused glassy vesicular material present in the core of this fulgurite, the outer portions were composed of baked or dried clay which also had a vesicular structure and which was very fragile and crumbled in the hand. Of equal, or even greater, interest was the observation that the small patch of disturbed ground formed the top of a very low conical mound with cracks in the soil radiating out from it (Fig 1). The diameter of the cone was about six metres and most of the ground surface was essentially intact with some small cracks and a slight unevenness of the surface. On walking on this area the surface gave way underfoot with my boot sinking up to 50 mm near the centre of the cone. It was the lack of any significant ground cover that allowed this feature to be recognised.

From the observations made of the features of the occurrence on Avoca Downs it is considered that the origin of these vesicular glass objects is most likely to be from lightning strikes and that they are therefore a variety of fulgurite. The Avoca Downs example only produced a small crumbly fulgurite but this discovery

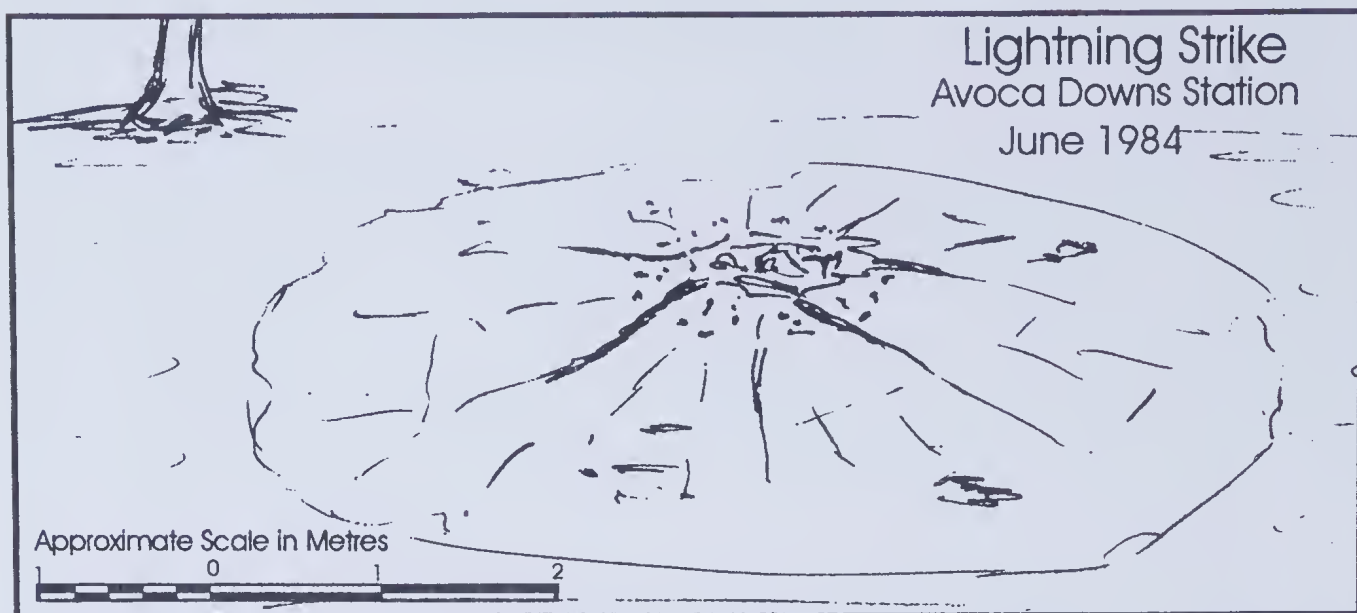


Figure 1. Sketch of the structure that resulted from the Avoca Downs lightning strike. The sub-surface soil has been expanded to a maximum of about 50 mm at the centre of the cone where the soil has been significantly disturbed with lumps having been thrown into the air.

renewed my interest in these objects. Study of further such objects found lying on the surface in this region of the goldfields revealed that a significant proportion of them exhibit a zonal structure, with a core of fused glass that grades outwards into less fused and more crumbly material. The remaining specimens appeared to be more highly fused but of course this might not be an original feature and these might be the cores of a larger fulgurites that had suffered erosion. Although this could be the case for some samples, a large proportion were judged to have an original glassy exterior extending over varying proportions of their surfaces. It is therefore possible to distinguish two morphologies of these fulgurites, one which has a glassy core grading outwards into baked clay and the other which is virtually totally composed of glass and has a glass skin extending over a variable proportion of its surface.

### Second Discovery

In May 1986 the author was mapping in the Eastern Goldfields near Mulgabbie Hill on Pinjin Station about 190 km north east of Kalgoorlie and approximately 60 km north of the Avoca Downs strike described above. Here, shortly after some thunder storms, a large recently formed mass of vesicular glass was found on the surface of the ground surrounded by the remains of an old tree stump. The inside surface, of what had once been part of a hollow trunk, was covered in charcoal and all that remained was a thin shell of wood with a jagged profile rising to a point about 2 m above the ground. The object was lying on the surface of the ground within this shell and was formed of jet black glass that had been formed recently since there was no sign of any dust on its surface. It was only in contact with the ground in two main areas and the concavities in the lower surface formed spaces between the vesicular glassy material and the surface of the soil. When found it had some teardrop shaped pieces of glass hanging by thin glass threads from the under side. The observed features of the object and its setting led to the conclusion that it is a fulgurite. The underlying

ground was loose soil containing charcoal fragments. It would appear from its position when found that, like the Avoca Downs fulgurite, it too had been thrown into the air at the moment of formation. Unlike the Avoca Downs occurrence, the Mulgabbie strike had not resulted in any visible widespread disturbance of the ground surrounding the strike outside of the old stump. The soil was loose and uncompacted inside the stump, which was probably a result of the lightning, but it is not known what condition it was in before the strike.

The Mulgabbie fulgurite is of fairly uniform thickness (generally less than 100 mm thick) but bent and irregular in shape; its maximum dimensions are just over 400 mm long by 300 mm across (Fig 2). When collected in 1986 the glass was black with a high vitreous lustre and very spectacular. A tear drop of glass that detached from the underside of the fulgurite still possesses the black, vitreous lustre (Fig 2B).

The specimen is composed almost entirely of glass. Minor areas of the surface have reddish soil sticking to them with one of the largest soil patches on one end suggesting that this may have been the main area of contact with the ground immediately after the strike. A significant proportion of the surface area of the fulgurite may be described as mammillated to botryoidal with the glass forming an almost continuous surface. Other areas have a "damaged" appearance with the internal vesicular structure visible. These surface types are shown in Fig 2C.

Since collection, the glass has started to devitrify and is now a dull, dark grey with a streaky appearance. Some areas of glass have the greenish-brown colours that the author has noted in some of the older fulgurites that he has observed. The Mulgabbie specimen weighs just under 3 kg. It has been donated to the Western Australian Museum.

### Factors modifying the effect of a lightning discharge

There are a number of factors that could determine the characteristics of a fulgurite formed by a particular strike.



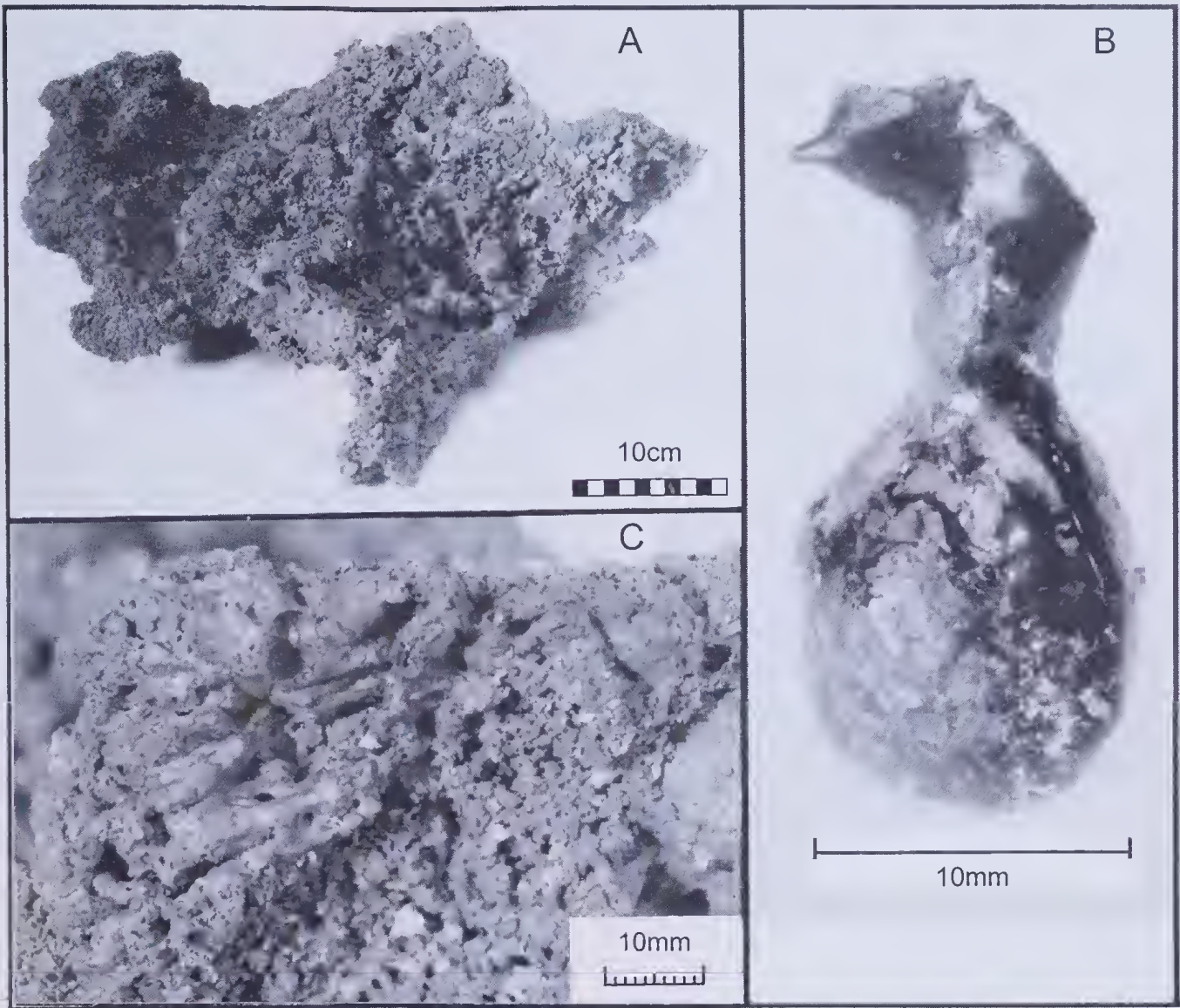


Figure 2. A: General view of the Mulgabbie fulgurite showing lower surface as found (scale bar = 10 cm). B: Glass tear drop which was hanging from lower surface by a glass thread when found (scale bar = 10 mm). C: Surface detail showing smooth sealed areas and areas with open vesicles (scale bar = 10 mm).

The primary factors are the energy of the discharge and the composition of the soil at the locality. Another significant factor is the conductivity of the soil. Sands are usually damp below the surface layers and I suggest that the reason sand fulgurites have their vertical narrow tapering form is that the sand is normally uniformly conductive so the discharge takes the shortest path and travels straight down. Lightning strikes in sand form narrow inverted conical tubes of silica glass that have been commonly traced to depths of over one and a half metres with a tapering diameter from 20 mm at the top to 3 mm at the bottom (Beasley 1963). In exceptional circumstances they have been traced up to 20 m deep (Bouska 1993). As the electrical discharge flows down into the damp sand the current is able to disperse, sometimes producing root-like protuberances of glass, and steadily becomes less intense with depth.

In the case of the Avoca Downs occurrence, the observed features are considered to support the interpretation that at the time of this strike there had been rain after an extended period of dry weather. The ground

at depth was therefore dry with a shallow damp surface layer due to recent rain. This would allow the electrical discharge to radiate out within the shallow and more conductive damp surface layer of soil. The discharge caused considerable heating that resulted in the development of steam and heated gases within the soil that expanded and raised the low conical structure. The radial dispersion of the electrical current may also have resulted in a less confined current at the point of entry of the discharge into the soil and consequently the reduced development of glass, and zoned structure, in the fulgurite that was formed.

Comparison of the two strikes

Comparing the Avoca Downs strike with that at Mulgabbie I considered that the latter was probably a more intense electrical discharge. It produced a large vesicular glassy fulgurite that was thrown into the air by escaping steam and hot gases. It had cooled sufficiently by the time that it sank back onto the surface of the ground to maintain much of its shape with only minor

areas in contact with the soil. The presence of the charcoal-covered wood sticking up out of the ground was probably a major factor in attracting the lightning discharge to this spot but there is no evidence to suggest the stump had burned to any significant extent at the time of the most recent strike.

The Avoca Downs strike may have been less intense and/or the energy of the discharge was dispersed due to the electrical current spreading out radially from the point of impact. The fulgurite formed was small and consisted of a glassy vesicular core surrounded by baked clay, which also had a vesicular structure. The observations made of the considerable disturbance to the surface layers of the soil surrounding this strike are considered to suggest that the distribution of moisture in clay soils can control the path taken by a lightening discharge and may be an important factor in determining the results of a particular strike.

### Conclusions

The observations that were made at the sites of these unusual occurrences, and of the glassy objects produced, are considered to indicate that they resulted from lightning strikes. They are considered to have confirmed that the fragments of glassy vesicular material that are found in the Eastern Goldfields are fulgurites from old lightning strikes. These vesicular fulgurites, which are formed when lightning strikes a clay soil, are very different from the narrow tapering silica tubes produced by lightning striking sand. They have not received the same attention as the sand fulgurites because once this type of fulgurite has been exposed to weathering for some time its origin is not obvious. As they are typically found lying loose on the surface, it is also not possible to determine if they are *in situ* or have been transported from elsewhere. The dark glass that forms the clay soil fulgurites and their vesicular character results from the different chemical composition of the clay soil compared to the relatively pure silica composition of many dune

sands. It is suggested that these fulgurites be referred to as "clay soil fulgurites" to distinguish them from the "sand fulgurites". A search of the references to fulgurites reveals that the majority of these papers refer to fulgurites that were formed by lightning strikes either in sand or in rock exposed on the peaks of hills and mountains, and the only reference that I have been able to trace describing "clay soil fulgurites" is that by Trendall (1964).

My observations on the Avoca Downs and Mulgabbie Hill occurrences of vesicular glass, and the associated phenomena, are considered to indicate that they resulted from recent lightening strikes. Although neither site was "still steaming" (which is the ultimate grade of freshness when it comes to lightning strikes) they were perfectly preserved and were judged to be days old rather than weeks old. These observations raise a number of questions about the behaviour of lightning discharges in dry clay soils with damp layers. It is hoped that further observation and interpretation of the results of fresh lightning strikes, by scientists who discover them while working in the field, will be able to confirm and increase knowledge of their behaviour in clay soils in various conditions.

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